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Assistant Commissioner for Patents	*Inventor(s)*	LOTSPIECH et al.
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Title of Application:

COINCIDENCE-FREE MEDIA KEY BLOCK FOR CONTENT PROTECTION FOR RECORDABLE MEDIA

Transmitted with the patent application are the following:

1	Page(s)	Transmittal form (and one copy)
13	Page(s)	Specification, claims, abstract
1	Page(s)	Formal Drawings
3	Page(s)	Declaration and Power of Attorney
1	Page(s)	Recordation Form Cover Sheet
2	Page(s)	Assignment of the Invention to International Business Machines Corporation

This application is a: ___ ***Continuation*** ___ ***Divisional*** _X_ ***Continuation-in-Part of prior application Serial No. 09/065,938, filed April 24, 1998.***

Fee Calculation

	Claims Filed		*Extra*	*Rate*	*Fees*
Basic Fee					$690.00
Total Claims	11	-20 =	0	× $18.00	00.00
Independent Claims	4	- 3 =	0	× $78.00	78.00
Multiple Dependent Claim				+ $260.00	-0-
				Assignment	$40.00
				TOTAL	$808.00

The Commissioner is hereby authorized to charge $808 to Deposit Account **09-0441** fees required under 37 CFR 1.16 or 1.17.

EXPRESS MAIL CERTIFICATE

I hereby certify that the above paper/fee is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated below and is addressed to the Assistant Commissioner for Patents, Washington, DC 20231

Date of Deposit: May 22, 2000

Person mailing paper/fee: Jeanne Gahagan

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COINCIDENCE-FREE MEDIA KEY BLOCK FOR CONTENT PROTECTION FOR RECORDABLE MEDIA

PRIORITY CLAIM

This application claims priority from co-pending U.S. patent application serial no. 09/065,938, filed April 24, 1998, incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to broadcast data encryption that uses encryption keys.

2. Description of the Related Art

The above-referenced application discloses a system for encrypting publicly sold music, videos, and other content. As set forth in the above-referenced application, only authorized player-recorders can play and/or copy the content and only in accordance with rules established by the vendor of the content. In this way, pirated copies of content, which currently cost content providers billions of dollars each year, can be prevented.

In the encryption method disclosed in the above-referenced application, authorized player-recorders are issued software-implemented device keys from a matrix of device keys. Specifically, the matrix of device keys includes plural rows and columns, and each authorized player-recorder is issued a single key from each column. The keys can be issued simultaneously with each other or over time, but in any event, no player-recorder is supposed to have more than one device key per column of the matrix. Using its device keys, an authorized player-recorder can decrypt a media key that in turn can

be used to decrypt content that is contained on, e.g., a disk and that has been encrypted using the device keys. Because the player-recorder is an authorized device that is programmed to follow content protection rules, it then plays/copies the content in accordance with predefined rules that protect copyright owners' rights in digitized, publicly sold content.

In the context of DVD audio disks, it is anticipated that each column in the media key block will contain 25,000 entries, with each entry representing the encryption of a common media key using one of 25,000 device keys. A single media key block might apply, for instance, to a batch of 100,000 DVD disks or other media, such as CDs, flash memory, and hard disk drives. An authorized device can use its device key to decrypt the entry pertaining to it, to thereby obtain the media key. The media key is then used to decrypt the content.

The present invention recognizes that since each device key disclosed in the referenced application is 56 bits long, to guess a particular key would require, on average, 2^{55} guesses, currently an impractically large number for a hacker to deal with. The present invention further recognizes, however, that since a single media key is encrypted once for each of, say, 25,000 device keys in a column, if a hacker obtained a media key block and the associated media key, the hacker could encrypt the media key with a guessed-at device key and then determine whether the result matches any of the 25,000 entries in the media key block column. If so, the hacker has compromised a device key that can then be provided to pirate (unauthorized) recorders to decrypt media key blocks from the current disk batch or any subsequent disk batch. If no match is found by the hacker, the hacker tries again with another guessed-at device key. This type of attack, referred to herein as a "coincidence" attack, consumes time but not so much that hacking a device key becomes impracticable. It is against this attack that the present invention is directed.

SUMMARY OF THE INVENTION

The invention includes a computer system for undertaking the inventive logic set forth herein. The invention can also be embodied in a computer program product that stores the present logic and that can be accessed by a processor to execute the logic. Also, the invention is a computer-implemented method that follows the logic disclosed below.

A method for is disclosed for complicating a coincidence attack in a system for protecting content on recordable media. The method includes providing a single media key, and Transforming the media key using a position-specific function with each of a sequence of positions to render a sequence of position-dependent media keys. The method also includes encrypting each position-dependent media key with a respective position-dependent device key.

In another aspect, a system for complicating a coincidence attack in a system for protecting content on recordable media includes a media key block (MKB). The MKB includes plural encrypted entries, and each entry has a position in the MKB. Each entry is established at least in part by combining the entry with its respective position.

In still another aspect, a computer program device includes a computer program storage device that in turn includes a program of instructions which can be used by an encryption computer. The instructions include logic means for receiving a media key, and logic means for altering the media key with each of a sequence of numbers to render a sequence of media keys. Logic means encrypt each key in the sequence of media keys with a respective device key associated with the respective number.

In yet another aspect, a computer program device a computer program device includes a computer program storage device that in turn includes a program of instructions which can be used by a decryption computer. The instructions include logic means for receiving a media key block (MKB) having plural

positions, with each position having a number related thereto. Logic means access a device key. The device key is associated with a position corresponding to one of the positions of the MKB. The position that is associated with the device key is known to the decryption computer. Logic means are provided for decrypting the number at a position in the MKB corresponding to the position associated with the device key to render a decrypted position-dependent media key. Then, logic means are invoked for reverse transforming the position-dependent media key with a number representing the position of the position-dependent media key in the MKB, to render a media key.

The details of the present invention, both as to its structure and operation, can best be understood in reference to the accompanying drawings, in which like reference numerals refer to like parts, and in which:

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a block diagram of the present system;

Figure 2 is a schematic diagram of a device key matrix;

Figure 3 is a flow chart of the encryption logic; and

Figure 4 is a flow chart of the decryption logic.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring initially to Figure 1, a system is shown, generally designated 10, for encrypting content in a broadcast content guard system, such as but not limited to the system disclosed in the first of the above-referenced applications. By "broadcast" is meant the wide dissemination of a program from a

content provider to many users simultaneously over cable (from a satellite source), or wire, or radiofrequency (including from a satellite source), or from widely marketed content disks.

As shown, the system 10 includes a content provider 12 that accesses a media key block (MKB) generator module 14 that functions in accordance with disclosure below to encrypt content on a content media 16. The MKB 18 is provided on the media 16. A player-recorder 20 can access a decryption module 22, which uses one or more device keys 24 to operate on the MKB 18 to decrypt the content on the media 16, again in accordance with disclosure below. As used herein "media" can include but is not limited to DVDs, CDs, hard disk drives, and flash memory devices.

It is to be understood that the processors associated with the modules 14, 22 access the modules to undertake the logic shown and discussed below, which may be executed by a processor as a series of computer-executable instructions.

The instructions may be contained on a data storage device with a computer readable medium, such as a computer diskette having a computer usable medium with computer readable code elements stored thereon. Or, the instructions may be stored on a DASD array, magnetic tape, conventional hard disk drive, electronic read-only memory, optical storage device, or other appropriate data storage device. In an illustrative embodiment of the invention, the computer-executable instructions may be lines of compiled C^{++} compatible code.

Indeed, the flow charts herein illustrate the structure of the logic of the present invention as embodied in computer program software. Those skilled in the art will appreciate that the flow charts illustrate the structures of computer program code elements including logic circuits on an integrated circuit, that function according to this invention. Manifestly, the invention is practiced in its essential embodiment by a machine component that renders the program code elements in a form that instructs

a digital processing apparatus (that is, a computer) to perform a sequence of function acts corresponding to those shown.

For a full understanding of the details of the preferred broadcast encryption scheme and how it can be used to defeat unauthorized copyists, reference is made to the above-referenced patent application. To summarize the preferred broadcast encryption logic set forth therein, however, as shown in Figure 2 a device key matrix 26 is generated, with each device key $S_{j,i}$ being a random number of predetermined bit size, in one preferred embodiment 56 bits or in another embodiment 64 bits. Per present principles, i= the integers from 1 to N inclusive and j= the integers from 1 to M inclusive, wherein M might equal, for example, 25,000. "I" is a key index variable and "j" is a sets index variable. Each authorized player-recorder is then assigned selected keys "S" from the matrix by a licensing agency, with each key being associated with its known position in the column, i.e., its "j" number, and thus with a player-recorder knowing both its device key and the device key's position in the matrix 26. For example, a first player-recorder might be assigned the keys $S_{3,1}$, $S_{5,2}$, $S_{1,3}$, $S_{1,4}$, $S_{6,5}$, $S_{4,6}$, and $S_{8,7}$. In any case, each player-recorder is assigned "N" device keys, and each player-recorder is assigned one and only one device key "S" for each key index variable "i" (i.e., for each column). Embodiments, however, wherein a device might not include a device key for each and every i^{th} position are within the scope of the above-referenced invention.

No single authorized player-recorder learns two keys at the same position in the key index dimension. Preferably, no player-recorder has exactly the same device keys "S" as any other device, although the device keys of many devices might overlap.

After having provided the device key matrix 26, a media key block (MKB) is constructed as follows. For each column, a random number is provided (or a version thereof hashed with a known

number) that establishes a media key. The media key is encrypted with each device key in a column. A single column of encrypted versions of media keys (or multiple columns, each representing its own media key) establishes a media key block (MKB) (also referred to in the above-referenced application as a "session key block"). A single MKB might be provided for, e.g., a batch of 100,000 content media.

When an authorized player-recorder receives content on, e.g., a disk, the MKB is provided on the media and is thus also received. Using its device key, the player-recorder decrypts the media key, and then using the media key the player-recorder decrypts the content. Further details of this operation is found in the above-referenced application. The present invention adds a step to the above-described operation to foil the above-described "coincidence" attack.

Specifically, commencing at block 28 in Figure 3, a random number that establishes the media key (or equivalently a hashed version thereof) is provided for each column of the matrix 26. Thus, every column is given the same media key. In one preferred embodiment, the length of the media key is sixty four (64) bits.

Moving to block 30, the media key of a column is altered in each position in the column using a position-specific function. In the presently preferred embodiment the media key is XORed with a number, e.g., an integer, representing a position in the "j" dimension to render a respective position-dependent media key. Thus, the media key is XORed with numbers representing each of the sequence of "M" positions in the "j" dimension to render a sequence of "M" position-dependent media keys. Other position-specific functions such as addition, subtraction, and so on can be used.

Then, at block 32 each position-dependent media key is encrypted with the device key having its position in the "j" dimension corresponding to the position of the position-dependent media key. In this way, the MKB 18 is rendered, and at block 34 it is associated with a batch of media.

Figure 4 shows that authorized player-recorders reverse the above steps to play the content. Specifically, at block 36, using its device key $S_{j,i}$ for the i^{th} column, a player-recorder decrypts the MKB, and more specifically decrypts the position-dependent media key at the j^{th} position in the MKB. Moving to block 38, the player-recorder reverse XORs the position-dependent media key with the number representing the j^{th} position to render the media key. At block 40 the media key can be used to decrypt content.

It will be appreciated that while an authorized player-recorder knows both a device key and its position in the matrix 26, a pirate who guesses at a device key might guess the correct key, but would also then have to guess its position, thereby transforming the above-described coincidence attack back into a problem that as a practical matter is not solvable.

While the particular COINCIDENCE-FREE MEDIA KEY BLOCK FOR CONTENT PROTECTION FOR RECORDABLE MEDIA as herein shown and described in detail is fully capable of attaining the above-described objects of the invention, it is to be understood that it is the presently preferred embodiment of the present invention and is thus representative of the subject matter which is broadly contemplated by the present invention, that the scope of the present invention fully encompasses other embodiments which may become obvious to those skilled in the art, and that the scope of the present invention is accordingly to be limited by nothing other than the appended claims, in which reference to an element in the singular means "at least one", not "only one", unless otherwise stated in the claim. All structural and functional equivalents to the elements of the above-described preferred embodiment that are known or later come to be known to those of ordinary skill in the art are expressly incorporated herein by reference and are intended to be encompassed by the present claims. Moreover, it is not necessary for a device or method to address each and every problem sought to be solved by the

present invention, for it to be encompassed by the present claims. Furthermore, no element, component, or method step in the present disclosure is intended to be dedicated to the public regardless of whether the element, component, or method step is explicitly recited in the claims. No claim element herein is to be construed under the provisions of 35 U.S.C. §112, sixth paragraph, unless the element is expressly recited using the phrase "means for" or, in the case of a method claim, the element is recited as a "step" instead of an "act".

WE CLAIM:

CLAIMS

1. A method for complicating a coincidence attack in a system for protecting content on recordable media, comprising:

providing a single media key;

Transforming the media key using a position-specific function with each of a sequence of positions to render a sequence of position-dependent media keys; and

encrypting each position-dependent media key with a respective position-dependent device key.

2. A system for complicating a coincidence attack in a system for protecting content on recordable media, comprising:

a media key block (MKB), the MKB including plural encrypted entries, each entry having a position in the MKB, each entry being established at least in part by transforming the entry using a number representing its respective position.

3. The system of Claim 2, wherein an entry is established by a media key.

4. The system of Claim 2, wherein each entry is established by the same media key as all other entries, the media key being combined with each of a sequence of positions to render a sequence of position-dependent media keys.

5. The system of Claim 4, wherein each position-dependent media key is encrypted by a respective device key.

6. The system of Claim 5, further comprising plural players, each having a device key of known position with which to decrypt the media key to play content encrypted with the media key.

7. A computer program device, comprising:

a computer program storage device including a program of instructions usable by an encryption computer, comprising:

logic means for receiving a media key;

logic means for altering the media key with each of a sequence of numbers to render a sequence of media keys; and

logic means for encrypting each key in the sequence of media keys with a respective device key associated with the respective number.

8. The computer program device of Claim 7, wherein each number represents a position in a key matrix.

9. The computer program device of Claim 8, wherein the means for altering XORs the media key with at least one of the numbers to render a key in the sequence of keys.

10. A computer program device, comprising:

a computer program storage device including a program of instructions usable by a decryption computer, comprising:

logic means for receiving a media key block (MKB) having plural positions, each position having a number related thereto;

logic means for accessing a device key, the device key being associated with a position corresponding to one of the positions of the MKB, the position associated with the device key being known to the decryption computer;

logic means for decrypting the number at a position in the MKB corresponding to the position associated with the device key to render a decrypted position-dependent media key; and

logic means for reverse transforming the position-dependent media key with a number representing the position of the position-dependent media key in the MKB, to render a media key.

11. The computer program device of Claim 10, further comprising logic means for decrypting content using the media key.

COINCIDENCE-FREE MEDIA KEY BLOCK FOR CONTENT PROTECTION FOR RECORDABLE MEDIA

ABSTRACT OF THE DISCLOSURE

A system for protecting content on recordable media for, e.g., DVD audio disks, flash memory media, or other media includes providing a media key block (MKB) on each media, with each MKB including 25,000 encryptions of a media key by 25,000 or so device keys. Each authorized player in the system has a single device key from among the system device keys with which to decrypt the media key. To avoid a coincidence attack in which a hacker can learn the MKB and associated media key and then guess at a device key without knowing its position in the MKB, the media key is XORed with a number representing each position in the MKB, and only then encrypted with the device key corresponding to that position.

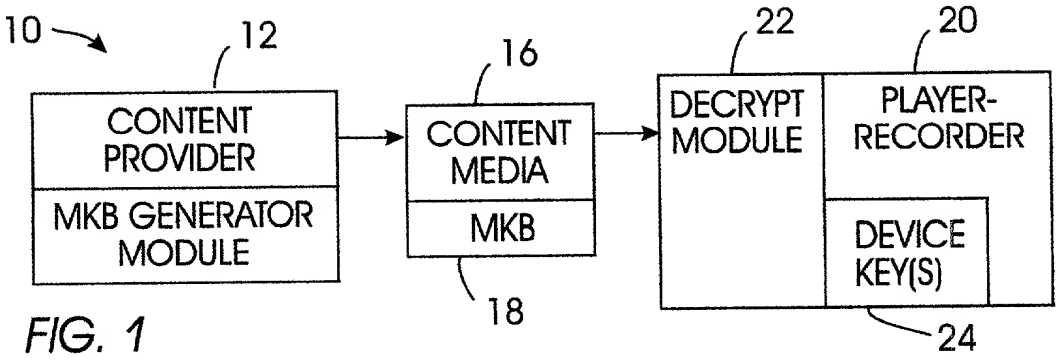

FIG. 1

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$S_{1,1}$	$S_{1,2}$	$S_{1,3}$	$S_{1,4}$	$S_{1,5}$	$S_{1,6}$	$S_{1,7}$
$S_{2,1}$	$S_{2,2}$	$S_{2,3}$	$S_{2,4}$	$S_{2,5}$	$S_{2,6}$	$S_{2,7}$
$S_{3,1}$	$S_{3,2}$	$S_{3,3}$	$S_{3,4}$	$S_{3,5}$	$S_{3,6}$	$S_{3,7}$
$S_{4,1}$	$S_{4,2}$	$S_{4,3}$	$S_{4,4}$	$S_{4,5}$	$S_{4,6}$	$S_{4,7}$
$S_{5,1}$	$S_{5,2}$	$S_{5,3}$	$S_{5,4}$	$S_{5,5}$	$S_{5,6}$	$S_{5,7}$
$S_{6,1}$	$S_{6,2}$	$S_{6,3}$	$S_{6,4}$	$S_{6,5}$	$S_{6,6}$	$S_{6,7}$
$S_{7,1}$	$S_{7,2}$	$S_{7,3}$	$S_{7,4}$	$S_{7,5}$	$S_{7,6}$	$S_{7,7}$
$S_{8,1}$	$S_{8,2}$	$S_{8,3}$	$S_{8,4}$	$S_{8,5}$	$S_{8,6}$	$S_{8,7}$

FIG. 2 - DEVICE KEY MATRIX

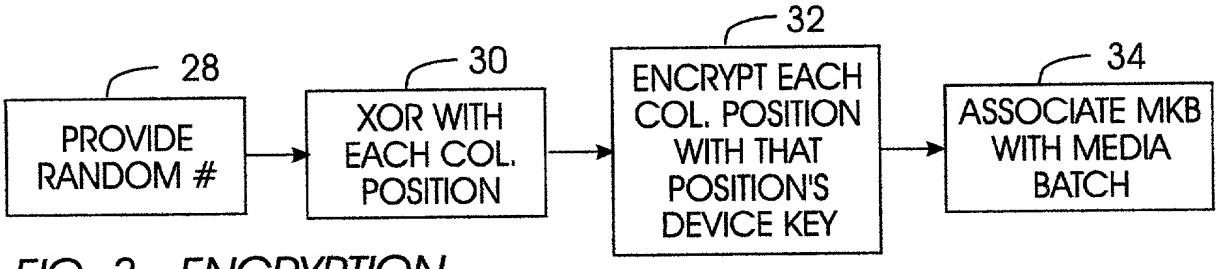

FIG. 3 - ENCRYPTION

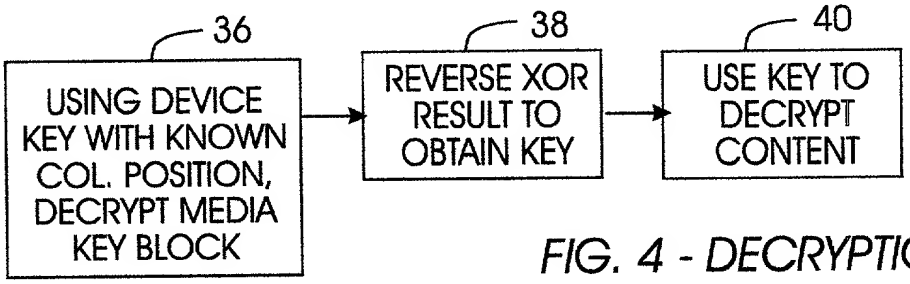

FIG. 4 - DECRYPTION

Docket No. AM9-98-028-US2

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

COINCIDENCE-FREE MEDIA KEY BLOCK FOR CONTENT PROTECTION FOR RECORDABLE MEDIA

the specification of which is attached hereto unless the following box is checked:

was filed on _____
as United States Application Number or PCT International Application Number _____
and was amended on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR §1.56.

I hereby claim foreign priority benefits under 35 USC §119(a-d) or §365(b) of any foreign application(s) for patent or inventor's certificate, or §365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s): **Priority Not Claimed**

(Number)	(Country)	(Day/Month/Year Filed)

I hereby claim the benefit under 35 USC §119(e) of any United States provisional application(s) listed below:

Provisional Application(s):

(Application Number)	(Filing Date)

I hereby claim the benefit under 35 USC §120 of any United States application(s), or §365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 USC §112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR §1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application.

(Application Number)	(Filing Date)	(Status - patented, pending, abandoned)
09/065,938	April 24, 1998	Pending

Power of Attorney:

I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

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Docket No. AM9-98-028-US2

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Docket No. AM9-98-028-US2

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

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